The effect of some botanicals on the infestation of wood by termite

By

Abdo Elmoniem Awad Atta Elmanan
B.Sc. (Honour) Forestry,
Faculty of Forestry University of Khartoum1998

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Supervisor: Prof. Hashim Ali El Atta

Department of forest Conservation and Protection
Faculty of Forestry, university of Khartoum
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Dedication

To my lover, the kind mother. To the soul of father, with love, gratitude and respect. To my brothers and sisters. To my dear Elshafae for his help during difficult times.

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ملخص الدراسة

هدفت هذه الدراسة لمعرفة أثر زيت البان (EO) وزيت بذرة النيم (NSKO) وبـودرة النيم (NSKP) والبان بتركيزات مختلفة علي حماية أخشاب المهوقني (*Khya senegalensis*) و(*Pinus spp.*) والموسـك (*Balanites aegybtiaca*) والهجلـيج (*Eucalyptus camaldulensis*) من الاصابة بالارضة..

كما هدفت الدراسة ايضا لمعرفة أثر هذه المستخلصات النباتية من النيم والبـان كبـدائل للدرسبان (Dursban.) في مكافحة الأرضة من هذه الأنواع النباتية التي تمت دراستها.

تم قطع هذه الاخشاب بحجم 3×5×30 سم ومن ثم معاملتها بالتركيزات المختلفة ثم دفنها في الارض حتي عمق 20سـم وذلـك فـي كـل 5 مكـررات عـشوائية بتركيـزات (10%،25%،50%).

تم اجراء هذه الدراسة في ارض بها اصابة بالارضة (مزرعة جامعة الخرطوم).

تمت متابعة التجربة بالملاحظات ورصد الاصابة وذلك خلال ثلاثة اشـهر مـن بدايـة تـصميم التجربة.

لم يتم رصد اي فروقات معنوية للاصابة بالارضة بين كل المعاملات وذلك حتي نهايـة الـشهر الاول من التجربة.

أثبتت الدراسة عند نهاية الشهر الثاني منها وجود فروقات معنوية للاصابة بالارضة بين الـشاهد وتركيز 50% للمعاملة بزيت النيم وتركيز50% للمعاملة ببودرة النيم وتركيز50% للمعاملة بزيت البان وذلك علي عينات المهوقني .

ايضاً اثبتت الدراسة وجود فروقات معنوية بين الشاهد والمعاملة بتركيز 50% بزيت البان وذلـك علي عينات البان.

اثبتت الدراسة عند نهاية الشهر الثالث من التجربة وجود فروقات معنوية للاصابة بالارضة بـين الشاهد وتركيز 50% للمعاملة بزيت النيم و25% و50% للمعاملة ببودرة النيم وذلك علي عينات المهوقني. ووجود فروقات معنوية بين الشاهد وتركيز 50% للمعاملة بزيت البـان وذلـك علـي عينات الهجليج . ووجود فروقات معنوية بين الشاهد وتركيز50% للمعاملة ببودرة النيم وتركيـز 50% للمعاملة بزيت البان وذلك علي عينات الموسك.

CHAPTER ONE

INTRODUCTION

In general, there are two main factors that influence the durability of timber in service. The first is the natural durability of the particular species. The second is the type and degree of hazard to which the timber is exposed. The natural durability of particular species is expressed by rating the timber in one of four durability classes. These classes are based on field trials of untreated heartwood in the ground and indicate the resistance of the heartwood of the species to fungal and insect (termite) attack. These classes are:

Class 1: Timbers of the highest natural durability, which may be expected to resist both decay and termite attack for at least 25 years and up to 50 years in the ground(Thornton and Jonhson,1968).

Class 2: Timbers of high natural durability, which may be expected to have a life of about 15 to 25 years in the ground.

Class 3: Timbers of only moderate durability, which may be expected to have a life of about 8 to 15 years in the ground.

Class 4: Timbers of low durability which may last from about 1 to 8 years in the ground. These timbers have about the same durability as untreated sapwood, which is generally regarded as Class 4, irrespective of species (Thornton and Jonhson,1968).

In our everyday lives we are surrounded by examples of wood, which are centuries old. Britain's towns, villages and farms contain an enormous array of wood, which has given good service for fifty years and more. Our coast and our rivers and our countryside show wood being routinely used in tough exposed places.

Wood has enemies. Among them are fungal decay, woodworm and marine borer, but they can be kept at bay .

Understanding the effects of the environment in which the wood will be used is important. It will dictate choice of wood product and whether additional protective substances have to be used (Stratford, 1980).

Control of termites by chemical insecticides has adverse effects on soil and environment in general. Insecticides may kill the soil inhabiting microorganisms, adversely affect chemical and physical properties of soil, human, plant and animal poisoning, skin allergy, carcinogenesis, attacks of asthma and some of them have persistent effect on the environment. In addition they are costly and may involve technical problems.

The present study was undertaken with the following objectives:

(1) To test the efficacy of some botanicals in controlling or minimizing damage by termites to wood blocks from indigenous as well as exotic tree species.

(2) To compare the efficacy of botanicals with a known pesticide.

(3) To study durability or otherwise resistance of the tested timber species against termites.

CHAPTER TWO

LITERATURE REVIEW

2. 1: Termites: -

2.1.1: Termite groups: -

Termites (Isoptera) are very ancient order of insects whose origins dated back to approximately 50 million years (Krishna, 1989). Although they are commonly called ‘white ants’ ,in many parts of world they have only a superficial resemblance to ants . In fact they are most closely related to the cockroaches. Termites play a prominent role in the disintegration and decomposition of dead wood and plant debris and hence in the recycling of plant nutrients (Krishna, 1989). Many species obtain the cellulose, which is the basis of their diet and of the more than 300 species of termites in Australia, Japan, Middle East and Africa, only few are of economic importance.

Species capable of attacking sound seasoned timber can be grouped to two categories: -

(1) Dry wood termites: They obtain the required water from the wood in which they feed and need no contact with the soil or with any other source of moisture.

(2) Subterranean termites: As implies, are generally grounds dwelling, require contact with the soil or some constant source of moisture (Nutting and Jones, 1990).

2.1.2: History and spread: -

Insects have existed on earth long before humans (Krishna, 1989). Termites, in particular have along history, although their behavior and body structure are similar to ants but did not evolve along the same line .In fact, termites evolved from the cockroach about 150 million years ago, Modern cockroaches are known to be one of the oldest and most successful insects on the earth. Perhaps this long legacy gives termites their a sounding tenacity and adaptability. Unlike cockroaches however, termites exhibit complex and rigid social interaction in a colony. Particularly tasks are performed by individuals specialized for the purpose(Krishna,1989).

2.1. 3: Termite ecology: -

Termites feed on dead plant cell wall materials such as wood, leaf litter, roots, dead herbs and grass, dung and humus. Chemically their food can be characterized, as lignocellulosic material, which is the most abundant organic material in biosphere. Termites are cable of digesting cellulose, and some species can also digest lignin with the assistance of symbiotic intestinal protozoa and bacteria (Waller et al., 1987). Many termites also have symbiotic relation with nitrogen fixing bacteria. In converting lignocellulosic biomass, termite production supports a large proportion of tropical vertebrate’s biodiversity including many species of amphibians, reptiles and ground foraging insectivorous (Nutting and Jones, 1990).

2.1.4: Termites biology and behaviour: -

Cellulose is the basic food requirement of all termites therefore all types of timber and plant material are liable to attack (Krishna, 1989). Some species of timber are resistant to termites, but none are entirely ‘termite proof’. In-man-invaded environments, termites often damage materials they can not digest e.g. Plastic, rubber, metal or mortar. This damage occurs when the indigestible items are encountered in the termite’s search for food. The worker termites that consume the wood they share their nourishment with other members of the colony. Termites have the habit of grooming each other with their mouth parts and food exchange often occurs at this time. Dead or dying members of the colony are also consumed. Termites search for food sources by moving inside subterranean galleries or covered runways, which extend from the central nest to food sources above or below ground. The gallery system of single colony may exploit food sources over as much as one hectare with individual galleries extending up to 100 m in length. Apart from grass-eating species, which forage in the open at night, all subterranean termites remain within a completely closed system of galleries, devoid of light. The only exceptions are during a swarming flight, repairing or building a new colony. The advantages of this closed system are two folds, they are protected from attack by natural enemies such as ants; and they gain a measure of protection from temperature and humidity extremes. Termites have only a thin ‘skin’ or integument and therefore have relatively little resistance to drying out. Consequently termites must maintain humidity in the nest in excess of 90 % to avoid desiccation. Subterranean termites including tree-nesting species primarily obtain their moisture from the soil. Usually they maintain continuous contact with the soil in order to survive, unless there is a constant above ground source of moisture like plumbing leaks or proofing leaks (Su and Scheffrahn, 1990).

2.1.5: Classification of termites: -

Termites’ classification and characters used for identification are briefly reviewed. In Kenya, representatives of the four families; Kalotemitidae, Rhintermitdae, Hodotermitidae and Termitidae have been recorded and 41 genera have been described; 16 of which have been revised and Macroterms and Odontoterms are currently being revised. About 100 species, the majority of which belong to the Termitidae are found in Kenya. Economically important genera are *Cryptotermes, Hodotermes, Coptotermes, Schedornintotermes, Microcerotermes, Amitermes, Pseudocanthotermes, Synacanthotermes, Allodontermes Odontotrmes Ancistrotermes, Microtermes, Trinerviterrmes, Naustitermes and grallototermes* (Bagine, 1992).

Recent tabulations indicated that since 1995 there were approximately 2,753 validly named termite species in 285 genera in the world.

The vast majority of termite species occur in tropics and only one species is resident in Ontario, the eastern subterranean termite *Reticulitermes flvipes* (Kollar, 1995).

2.1.6: Colony of Termites: -

Like ants, wasps, and bees, termites are social insects. They exhibit brood care within their social community or (colony). A colony is a very large family of insects. Some the off spring diverge from the normal course of development to become various castes. Unlike most insects which have only one linear development pathway, termites have branching developmental pathways, therefore, they are polymorphic (Kollar, 1999). Termites work and live together in colonies and care for their young, each is composed of workers, soldiers, juveniles and at least one pair of reproductives (The king and the gueen). Winged termites (alates) my be present at certain times each year and usually swarm in spring to early summer or early autumn (Baroni et. al, 1978).

Krishna 1989 indicated that most species of termites are able to produce supplementary reproductives which are potential alates but don't leave the colony during swarming flights.

2.1.7: Distribution of Termites: -

There are about fifteen species of subterranean termites which commonly attack timber-in-service throughout Austeralia and ten of these occur in Qeensland (Krishna, 1989).The most serious pest is *Coptotermes asinaiformis* and the giant termite *Mostotermes darwiniensis*. The former occurs throughout Queensland while Mastotermes in confined to the tropical northern region. Other species that commonly damage timber are *Schedorhinotermes itermedius seclusus, Nasutitermes exitiosus, Coptotermes frenchi* and *Coptotermes lacteus.* Soil type appears to have an important influence on termites. For example *Mastotermes darwiniensis* does not occur in rainforest soils or in the extensive bauxite soil of Cape York Peninsula, however other termite species which damage timber may occur in these areas. The physical characteristics of the heavy soils, which crack deeply and widely in dry conditions and become waterlogged after rain do not favour termite survival. Although, the coastal belt and northern parts of Queensland are generally regarded high hazard areas for subterranean termite invasion (Krishna, 1989).

2.1.8: Economic importance of termites: -

In Kenya, it was stated that termites are the most destructive of insect pests (Kabiru, 1992). There are about fifteen species of subterranean termites which commonly attack timber (Krishna, 1989).

Termites are reported to cause damage and crop losses in maize field, and to destroy stored maize (Kibata, 1992).

Most subterranean termites feed along the grain of the wood, eating the springwood and leaving the summerwood. The Formosan termites feed on both and form a hallow. If the hallow is large (tree or timber) it is then filled with carton material to form anent. Subterranean termites construct tunnels (Foro galleries) from the nest to infest wood (Krishna, 1989). Termite damages is considered to be a major constraint to the timber use, such as Eucalyptus ssp, by small holders in western Kenya. In some areas damage is also observed in crops such as maize and sorghum. The damage was thought to be caused mainly by Macrotermes bellicosus and Odototermes badius is little (Amadolo, 1992).

2.2.10: Control of termites: -

Termites control can be divided into two types, pesticidal and non-pesticidal.

2.1 .10 .1: Pesticidal control: -

The chemical control is through pressure impregnation of timber with copper – chromo – arsenate or hot creosote that has proved to be quite successful against termites. Ground treatments against subterranean species have also been used (Kabiru, 1992). Mailu (1992) noted that restrictions on the use of persistent chlorinated hydrocarbons (aldrin and dieldrin) have necessitated new termite control products or alternative control strategies. Generally, fumigation is not recommended to control termites. It may be necessary to apply fumigant gas to kill auxiliary nests (Waller and Fage, 1987).

2. 1.10.2: Non pesticidal control: -

Some aspects of non pesticidal control need proper identification of the termite pest so that a control method appropriate to a particular species can be used (Logan, 1992) Generally, there are some non pesticidal controls such as:

(A) Physical treatment: -

Such as gamma and X-ray irradiation (Myles and Grace, 1991).

(B) Biological control: -

Termites have a wide range of natural enemies including birds, mammals, humans and invertebrate predators. Effective biological control agents such as microbial pathogens, have greatest potential (Ochiel,1992).

(C) TTR (Trap- Treat- Release): -

Trap- treat- release is a new technique for subterranean termite control (Myles, 1994). The procedure involves three main steps

(1) Trap: -

The termite trap consists of a plain cardboard roll fitted inside a plastic sleeve. The trap is about 15 cm high and 15 cm in a diameter the lid is about 20 cm x 20 cm.

(2) Treat: -

When treating the termites, a topical application of sulfuramide formulation is blotted directly on to termite’s dorsal services, the termites are now ready for release.

(3) Release: -

The treated termites are placed in cardboard roll and returned to the site from which they come. Treated termites are then able to spread the toxicant to the rest of the colony.

2.2: Natural pesticides: -

2. 2.1: Neem Seed Oil: -

The neem tree (*Azadirachta india Juss*.) probably originated in India or Burma, where its medical and insecticidal proprieties are well known.

Furthermore neem oil is used on small industrial scale for soap production (Schmutterer, 1981). At the beginning of the last century the neem tree was introduced to many other tropical countries especially in Africa. Many of neem tree properties are still unknown and it is mostly used for firewood and as a shade tree (Anonymous, 1982). The research results to date indicated that there are several active compounds, which are mostly concentrated in the seeds. Some of them inhibit larval development and reduce female fertility in various insect species by blocking insect hormones. Others act as repellents or anti – feedants. The compounds are most effective against Coleoptera, lepidoptera and Orthoptera. Results against some bugs, leaf hoppers and white flies have also been good (Schmutterer and Ascher, 1980).

2.2.2: Practical uses: -

The neem tree is fast growing and drought resistant therefore it's widely used to reforest semiarid areas. Neem seeds contain up to 45% oil, which can be used as fuel for lamps. Neem seed cake (resides of oil extraction), when used for soil amendment or added to urea or ammonia containing fertilizer, not only enriches the soil with organic matter, but also lowers nitrogen losses by inhibiting nitrification (Schmutterer and Aschcer, 1980).

2.2.3: Harvest and treatment of seeds: -

The harvest of ripe fruits needs them to be pulped and to avoid infection by fungi the grain must be washed by water after collecting them. For further processing (oil, water extracts) the kernels should be well dried by spreading on a hard ground in he sun and to avoid mounding. Kernels should be stored in a well-aerated recipient. Kernels should not be stored in plastic bags, moulding can be due to aflatoxin producing fungi, which are highly toxic to human beings even in low concentrations (Dreyer, 1995).

2.2.4: Oil production: -

There are two methods for oil production, namely: -

2.2.4.1: Oil production by hand:

To press neem oil by hand, the kernels have to be decorticated. Stones or big mortar are used to crush the kernels (Dreyer, 1995).

2.2.4.2: Oil production by machine:

By using an explore oil press there is no need to decorticate the neem seeds. Any of other oil seeds machine, can be used (peanuts, sesame, etc) after testing those with neem seeds if they are suitable. Moreover heating of oil will not affect its insecticidal purpose (Dreyer, 1995).

Dreyer (1995) noted that to make 2~4 ml of oil per kg of threshed beans, the beans and the oil have to be thoroughly mixed. This is best done in a big pot and beans are treated portion by portion. Neem oil has a bitter taste and to avoid any chance of influence in taste when the oil is used to treat edible material, the beans should be soaked for about 5 minutes in hot water before further preparation.

2.2.5: Azadirachtin: -

One of the most active ingredients isolated from neem is azadirachtin which proved to be the main agent for controlling insects.

It appears to cause some 90% of the effect in pests. (It doesn't kill the insects immediately, instead it both repels and disrupts the growth and reproduction of the insect (Arcade, 1998). Research has shown that azadirachtin is one of the most potent growth regulators and feeding deterrents ever studied.

The pests which are controlled by azadirachtin are Aphids, Army worms, Beet army worms, Brown plant hopper, Caterpillars chinch bugs, Colorado potato beetle, Cotton boil warm, Cowpea weevi desert locust, Diamondback moths, Leaf beetles, Sorghum shoot fly spotted cucumber beetle, Sweet potato white flies thrips, leaf miners, plant bugs, red cotton bug and red flour beetle (Arcade and Annagar, 1998).

Other ingredients active from neem:-

(1) Neem cake:

Arcade (1998) noted that neem cakes are organic fertilizers. Oil seedcakes are rich in azadirachtin and prevent attacks from harmful nematodes while promoting healthy crop growth.

(2) Neem tree bark powder:

Arcade and Annangger (1998) indicated that neem tree bark powder is natural product with tremendous potential for use in premium beauty and health care products.

2.2.6: Neem leaves: -

The seeds have about twice the potency of leaves, but seeds are only available for 3-4 months each year. Leaves are dried in the shade (the ultra – violet light from the sun may break down the active ingredient) and when the leaves are dry, they crushed to a powder in a mortar and pestle. They can then be used directly for dusting crops or as a powder in stored foods. The powder can also be mixed with water and sprayed on crops. (Siddig, 1991). The main effect is repellency. If the insects do eat the treated plant, neem has hormonal and growth regulation effect. Grasshoppers avoided treated plants and farmers who treated watermelon seeds with neem powder stated that rats which normally eat the seeds, did not eat the treated seeds.

2.2.7: Neem leaf tea to control termites: -

A br or bucket is filled with green neem leaves. Water is added and after 4 days the liquid is used against termites. Most of the time when farmers use it, it has been setting for at least 2 weeks and when the termites are starting up a tree or pole, they knock them down and their clay off then they take a paint brush and paint the whole area where the termites had been on and this treatment is repeated for the second time after about a week. But all the other times they have only done it once and the termites have not come back in time for about 5 or 6 months (Bostid, 1980).

When 40 mg powdered leaves in water (1:1) were applied to food plants of 4th instar nymphs they decreased the daily consumption of the grass hoppers by 22% (a significant reduction compared to untreated controls) and caused significant reduction in longevity relative to individuals fed on untreated foliage. At highest neem concentration of 0.0001% (100mg in 1-liter water), daily consumption was reduced by 77% (Joshi et al., 2000).

2. 3: Eucalyptus oil: -

2. 3. 1: Eucalyptus tree: -

The genus *Eucalyptus* belongs to family Myrtaceae, order Myrtiflorae, subclass Archlanydeae, class Angiosperm (Engler, 1930). *Eucalyptus* leaves are narrow and up to 30 cm long with short twisted petiole. The lamina is thick, quite glabrous but punctate from the presence of numerous oil glands situated in mesophyll. The surface is freguenly marked with a number of minute, warty brown spots (Wallis, 1960).

2. 3. 2: Chemistry of *Eucalyptus*: -

Among the species of this genus investigated to date production of volatile oils appears to be the major feature. Fresh leaves contain from 3 to 5% of volatile oils. The oil contains a bitter principle which has not been investigated and several resins one of which is crystalline (Wallis, 1960). More than 300 species of *Eucalyptus* are recognized by botanists and several different chemical races of subspecies may exist. For this reason the chemistry of various *Eucalyptus* oils, is an extremely complex subject. According to the major compounds in the volatile oil of *Eucalyptus* and consequently its uses, Varro et al (1981), divided them into 3 classes:

(I) *Eucalyptus* oil intended for medical use; contains 70-85% cineol, plus lesser amounts of volatile aldehydes, terpens, seguinterpens, aromatic aldehydes and alcohols and phenol. Many of these minor components have irritant properties and are removed by redistillation of the oil.

(II) Oils intended for industrial purposes; have pipertone and/or phellendrene as the principle components.

(III) Other *Eucalyptus* oils are used in perfumery as they are rich in geraniolits esters and citronellal.

On account of the wide adaptability of chemistry and biological activities more than 750 species of *Eucalyptus* spp indigenous to Australia and the islands of that region, have now been introduced for cultivation in many parts of the world. *Eucalyptus* have been a traditional source of timber , cellulose –related products and essential oils from the leaves . Less than 200 non- volatile secondary metabolites that have been characterized from different *Eucalyptus*, these are listed and discussed in relation to their chemical structures and biological activities. Many phloroglucionl derivatives from various *Eucalyptus* have growth regulatory, antigranulation, antiinflammatory and antimalarial activities. Rutin {rutoside}, (vitamin P) and other flavonoids, terpenoids and tannins extractable from *Eucalyptus* are of great pharmaceutical importance (Singh et al., 1999).

2. 3. 3: Oil extraction: -

E. globulus volatile oil was isolated by supercritical CO2 extraction with a fraction separation technique. A good extraction performance was obtained by operating at 90 bar and 50 °C for 510 min. The optimum fractionation was achieved by operating at 90 bar and –10 °C in the first separator and at 15 bar and 15 °C in the second one. The influences of the extraction and extraction time on the oil composition were also evaluated. A comparison with the hydrodistilled oil is also given (Della et al,1999).

2. 3. 4: *Eucalyptus* oils for controlling of pests: -

In field trials, *Eucalypyus* oils were tested for the control of broomrape (*Orobanche cernua*) in tobacco. The oils were applied to young , unflowered the oils effectively killed the parasitic shoots . Broom rape shoots at 1-5 drops/ shoot with a dropper. The optimum dosages being 1 drop/ shoot. It took one drop of *Eucalyptus* oil to kill the buds of broom rape (Krishnamunrthy and Chari, 1991).

Exposure of the 1 st- instar nymphs of *Dysdercus koengii* between 24 and 48 hour-old to *Eucalyptus* oil odour for 2 hours resulted in greater mortality in the third instar. Adults that did emerge were reduced in size. Treated adults laid fewer eggs, of more males emerged than females. Females that had reduced viability, as compared with untreated females. If the insects were exposed to *Eucalyptus* oil during embryogenesis, this reduction in breeding potential did not occur (Srivastava and Krishna, 1992).

Bagherwal (1999) tested *E. globulus* (in an emulsifier base) initially against developmental stages and adults of *Hyalomma anatolicum anatolicum* by placing them on filter paper impregnated with a 1: 4 dilution of the preparation. The average mortality of the unfed larvae, nymphs and adults was 100,89.2 and 74%, respectively. There was a 100% inhibition of egg laying and hatchability and engorged female ticks.

During antifungal evaluation of essential oils of some *Eucalyptus* spp., *E. citriodora* was most effective as an antifungal against *Microsporum nanum*, *Trichophyton mentagrophytes* and *T. rubrum*. While the pure oil (100%) killed *M. nanum*, *T. mentagrophytes* and *T. rubrum* .Comparing the minimum effective concentrations of the oil with those of prevalent synthetic antifungal drugs, the oil was more effective .It did not exhibit any adverse side effects on mammalian skin up to 5% concentration. The oil in the form of ointment broad-spectrum antimycotic drug (BSAD) was projected to topical testing on patients attending the outpatient department of M.L.N medical college, Allahabady India. All patients showed positive KOH results at the beginning of the trial. Patients were diagnosed with either *Tinea pedis* or *Tinea cruris*. After the second week of treatment all patients were KOH -Negative .At the end of third week of treatment every patient was KOH-.Negative .At the end of treatment, while 55.57 of patient recovered completely, 44.5 % showed significant improvement from the disease (Shahi et al.,1999).

CHAPTER THREE

MATERIALS AND METHODS

3. 1. Plant materials: -

3. 1. 1. Neem seed collection:

Healthy seeds of *A. indica* were collected from Forestry Research Center (Soba) in December (1999). The age of the mother trees from which the seeds were collected was10-25 years.

3. 1. 2. Neem seed kernel powder: -

Healthy seeds of *A. indica* were pressed by hand after soaking in water for 2 days to split out the seeds from the juice of fruits. Later the seed kernels were crushed using a mortar. This procedure was conducted at the Institute of Environment Research in (Khartoum) according to Siddig method.(Siddig,1991).

3. 1. 3. Neem oil extraction:

The oil used in this study was extracted by soxhlet extraction method as described in the British pharmacopoeia 1980.(British pharmacopoeia, 1980)

1250 grams of crushed neem seed kernels were subjected to a continuous extraction with petroleum ether (40-60^{o}C) in a soxhlet apparatus for 16 hrs.

The material was identified at the Industrial Research Center, Khartoum North.

3. 1. 4: Neem oil concentrations:

Three concentrations of neem oil were prepared in this study. These were 10, 25 and 50% (V/V) using petroleum ether as a diluting agent.

3. 1. 5: Neem seed kernel powder preparation:

Neem seed kernel powder used in the experiments was prepared according to Siddig (1991). The seeds of neem tree were obtained from Forestry Research Center (Soba). The fruits were soaked in water for 2 days and washed by hands to remove the juice and flesh. The seeds were then air dried on a mesh for 5 days. The kernels inside the seeds were extracted by breaking the seed coat and winnowing. The kernels were then husked by mortar and converted into powder.

3. 1. 6: Neem seed kernel powder concentrations:

Neem seed kernel powder was suspended in distilled water. It was prepared as 10, 25, and 50% (w/v) using distilled water as a diluting agent.

3. 1. 7: Collection of E. *camaldulensis* leaves:

The mature leaves of *E. camaldulensis* were collected randomly from the college of Agricultural Studies (Shambat) in December (1999) after being identified at the Faculty of Forestry, Khartoum university.

3. 1. 8: Extraction of E. *camaldulensis* oil:

The volatile oil of E. *camaldulensis* used in this study was extracted by water distillation method according to the British Pharmacopoeia 1980. Drying of leaves was done by exposing the leaves to dry air in a dark room at 22^{o}C for 2 days. The dry leaves were cut into small pieces and then extracted. One kilogramme of dry leaves was introduced into 20 liter still made from copper coated with tin (to avoid reaction with materials). Seven litres of tap water was added. Distillation was carried out for two hours after boiling until there was no further increase in the oil volume was observed. After cooling at room temperature, the oil was collected by separation on a separation funnel and dried over anhydrous sodium sulphate and then kept in a dark or brown bottle until used.

3. 1. 9: Concentration of *E.camaldulensis* oil:

Crude oil was diluted to 10, 25 and 50% (v/v) using petroleum ether as a diluting agent.

3. 1. 10: Physical properties of *Eucalyptus* oil: -

3. 1. 10. 1: Odour:

Odour was determined according to the method described in Indian standard (1967) depending on natural olfactory sense.

3. 1. 10. 2: Refractive index:

Refractive index of the samples was determined by using Abb-60 refractometer at temperature (22^{o}C) as described in AOAC (1970).

3. 1. 10. 3: Specific gravity:

Specific gravity was determined by using a pycnometer (density bottle) according to the AOAC (1970) methods at temperature (22°C).

3.1.10.4: Colour:

Colour was determined by using a tintometer according to the Instructions for using the lovibono tintometer method.

3. 2 : Application of botanicals to wood blocks:

Samples of wood (30x5x3cm) from four tree species *(Khaya senegalensis A.Juss, E. camaldulensis, Balanites aegybtiaca Del. and Pinus spp*.) were treated with neem oil, E.camaldulensis oil (10%, 25% and 50%) , three concentrations of neem seed kernel powder (10%, 25% and 50%) and 2% Dursban against termites. The samples of the tree species were treated using paintbrush method. Latter the samples were emmersed in Shambat soil (Khartoum university farm) at a depth of 20cm for 4 months.

Four replicates of each sample of treatments were made. The distance between any sample and another is100 cm and all the samples were allocated using completely randomized design (CRD).

The loss of weight (impact) attributed to termites effects were recorded monthly and the results were compared statistically using ANOVA and LSD.

3. 3: Moisture content of wood blocks: -

Moisture content was determined by using oven at 105°C according to the AOAC (1970) method.(AOAC,1970).

CHAPTER FOUR

RESULTS

4. 1. 1: Physical properties of *A. indica* oil:-

The physical properties of *A. indica* oil (colour, odour and taste, refractive index at temperature 22^0C and density) were determined. Table (1) summarizes the physical properties of neem seed kernel oil with their corresponding values.

Table (1): - The physical properties of neem seed kernel oil with their corresponding values.

Physical property	value
(1) Colour.	yellow and red 4.3 & 5.3
(2) Odour and taste.	dark,bitter and smelly, pungent odour.
(3) Refractive index at temperature 22^{o}C.	1.5310
(4) Density.	0.9060

4. 1. 2: Physical properties of *E. camaldulensis* oil: -

The physical properties of *E. camaldulensis* oil (colour, odour and taste, refractive index at temperature

22^0C and density) were determined. Table (2) summarizes the physical properties of *E. camaldulensis* oil with their corresponding values.

Table (2): - The physical properties of Eucalyptus leaves oil with their corresponding values.

Physical property	value
(1)Colour	Yellow and red 4.0 & 3.0

(2)Odour and taste characteristic aromatic

Comphraceous odour, pungent

and compharceous taste.

(3) Refractive index 1.4680

(4) Density 0.9080

4. 2: Effect of neem oil (NSKO), neem powder (NSKP), *Eucalyptus camaldulensis* oil (EO) and Dursban (D) against termites: -

4. 2. 1:Effect of neem crude oil, neem powder, Eucalyptus oil and dursban on wood blocks: -

Effect of treatments on the four woody species with neem crude oil, neem powder, Eucalyptus oil and dursban was significant. The loss of weight % of the blocks was significant for the treated species.

4. 2. 1. 1:Effect of (NSKO), (NSKP), (EO) and (D) on blocks (after 0ne month):-

4. 2. 1. 1. 1:Effect of (NSKO), (NSKP), (EO) and (D) on *K.. senegalensis*:-

Mean loss of weight % of the blocks treated was not significant as compared to control. But there are minor weight losses of the control blocks (6.1%) and blocks treated by 10% NO (4.3%) and this difference was not significant.

4. 2. 1. 1. 2:Effect of (NSKO), (NSKP), (EO) and (D) on *E. camaldulensis:-*

Mean loss of weight % of the blocks treated was not significant as compared to control. But there is minor weight losses in control blocks (5.0%), blocks treated by: 10% NO(1.8%), 25% NO (3.5%), 50% NO (1.0%), 10% NSKP (1.8%), 25% NSKP (2.1%) and 50% NSKP (2.7%) and this difference was not significant.

4. 2. 1. 1. 3:Effect of (NSKO), (NSKP), (EO) and (D) on *B. aegybtiaca:-*

Mean loss of weight % of the blocks treated was not significant as compared to control. But there is minor weight losses in: control blocks (3.0%), 10% NO(1.0%), 25% NO (3.8%), 25% NSKP (4.0%) and 10% EO (1.2%) and this difference was not significant.

4. 2. 1. 1. 4:Effect of (NSKO),(NSKP) , (EO) and (D)on *Pinus spp.*:-

Mean loss of weight % of the blocks treated was not significant as compared to control. But there is minor weight losses in: control blocks (0.5%), 10% NO(1.0%), 25% NO (0.5%), 10% NSKP (1.5%), 25% NSKP (0.5%), 50% NSKP (1.0%), 10% EO (1.5%) and 25% EO (0.4%) and this difference was not significant.

4. 2. 1. 2:Effect of (NSKO), (NSKP), (EO) and (D) on blocks (after two months):-

4.2.1.2.1:Effect of (NSKO), (NSKP), (EO) and (D) on *K.. senegalensis*:-

Effect of different concentrations of NSKO, NSKP, EO and D on *K. senegalensis* blocks is summarized in table (3); Fig (1).

Table (3): - The effect of (NSKO), (NSKP), (EO), and (D) and on *K. senegalensis* against termite infestation.

Treatment/concentration	Mean loss of weight %.
0% Control	0.15 b
10% EO	0.14 cb
25% NSKO	0.12 bc
10% NSKO	0.12 bc
25% EO	0.09 cbd
25% NSKP	0.08 cbd
10% NSKP	0.08 cbd
50% NSKP	0.06 ced
50% NSKO	0.03 ed
50% EO	0.03 ed
2% D	0.00 e

Means denoted with the same letter in acolumn are not significanly different at p=0.05

Mean weight loss % was significantly reduced in blocks treated with 50% NSKO, 50% EO, 50% NSKP and 2% D when compared with the control. There is significant defference between blocks treated with 2% D and 10%NSKO, 25%NSKO, 10%NSKP,10%EO, 25%EO and 50% EO.There is no significant difference between blocks treated with 2% D and 25%NSKP, 50%NSKP, 50% NSKO and50% EO.

There is no significant difference in weight loss between the control and 10%NSKO, 25% NSKO, 10%NSKP, 25% NSKP,10%EO and 25% EO (see table 3).

4. 2. 1. 2. 2:Effect of (NSKO), (NSKP), (EO) and (D) on *E. camaldulensis:* -

Effect of different concentrations of NSKO, NSKP, EO and D on *E. camaldulensis* was summarized in table (4); Fig (2).

Mean weight loss % was significantly reduced in blocks treated with 50% EO and 2%D when compared with the control.There is significant defference between blocks treated with 10%NSKO, 50%NSKO, 10%NSKP, 25%NSKP, 10% and 25% EO, and 2% D. There is no significant difference between blocks treated with 2% D and 25%NSKO, 50%NSKP and 50% EO.

Table (4):- The Effect of different concentrations of NSKO, NSKP, EO and D on *E. camaldulensis* against termite infestation.

Treatment/concentration.	Mean loss of weight %
0% C	0.19 a
10% EO	0.17 a
50% NSKO	0.14 ab
10% NSKO	0.14 ab
25% NSKP	0.13 ab
25% EO	0.13 ab
10% NSKP	0.13 ab
25% NSKO	0.11 abc
50% NSKP	0.1 abc
50% EO	0.08 bc
2% D	0.04 c

There is no significant difference in weight loss between the control and 10% NSKO, 25%NO, 50% NSKO, 10% NEKP,25% NSKP, 50% NSKP,10% EO and 25% EO (see table 4).

4. 2. 1. 2. 3:Effect of (NSKO), (NSKP), (EO) and (D) on *Balanites aegybtiaca: -*

Effect of different concentrations of NSKO, NSKP, EO and D on *Balanites aegybtiaca* was summarized in table (5); Fig (3).

Table (5):- The Effect of different concentrations of NSKO, NSKP, EO and D on *Balanites aegybtiaca* against termite infestation.

Treatment/concentration.	Mean loss of weight %.

25% NSKP	0.22 a
10% EO	0.22 a
25% EO	0.15 ab
0% C	0.15 ab
10% NSKO	0.14 ab
25% NSKO	0.13 b
10% NSKP	0.13 b
50% EO	0.11 b
50% NSKP	0/07 bc
50% NSKO	0.07 bc
2% D	0.02 c

Mean weight loss % was significantly reduced in blocks treated with 2%D when compared with the control.There is significant defference between blocks treated with 10% NSKO, 25% NSKO, 10% NSKP, 25% NSKP, 10% EO, 25% EO and 50% EO and 2% D. There is no significant difference between blocks treated with 2% D and 50% NSKO, 50%NSKP.

There is no significant difference in weight loss between the control and 10% NSKO, 25%SKNO, 50% NSKO, 10% NEKP,25% NSKP, 50% NSKP,10% EO, 25% EO,50% EO (see table 5).

4. 2. 1. 2. 4:Effect of (NSKO), (NSKP), (EO) and (D) on *Pinus spp.*: -

Effect of different concentrations of NSKO, NSKP, EO and D on *Pinus spp*. was summarized in table (6); Fig (4).

Mean weight loss % was significantly reduced in blocks treated with 2%D when compared with the control.There is significant defference between blocks treated with 10% NSKO, 25% NSKO, 50%NSKO, 10% NSKP, 25% NSKP, 50% NSKP 10% EO, 25% EO and 50% EO and 2% D.

There is no significant difference in weight loss between the control and 10% NSKO, 25%NSKO, 50% NSKO, 10% NSKP,25% NSKP, 50% NSKP,10% EO, 25% EO,50% EO (see table 6).

Table (6): - The Effect of different concentrations of NSKO, NSKP, EO and D on *Pinus spp*. against termite infestation.

Treatment/concentration.	Mean loss of weight %.

10% EO	0.20 a
0% C	0.18 ab
10% NSKP	0.16 ab
10% NSKO	0.16 ab
50% EO	0.15 ab
25% NSKP	0.15 ab
25% NSKO	0.15 ab
25% EO	0.12 ab
50% NSKP	0.11 ab
50% NSKO	0.09 b
2% D	0.00 c

4. 2. 1. 3: Effect of (NSKO), (NSKP), (EO) and (D) on blocks (after threemonth):-

4. 2. 1. 3. 1:Effect of (NSKO), (NSKP), (EO) and (D) on *K.. senegalensis*: -

Effect of different concentrations of NSKO, NSKP and EO on *K..* *senegalensis* blocks was summerized in table (7); Fig (5).

Table (7): - The Effect of different concentrations of NSKO, NSKP, EO and D on *K.senegalensis* against termite infestation.

Treatment/concentration.	Mean loss of weight %.
0% C	0.16 a
25% NSKO	0.13 ab
25% EO	0.13 ab
10% NSKO	0.12 ab
50% EO	0.11 abc
10% EO	0.11 abc
50% NSKP	0.08 bc
25% NSKP	0.08 bc
10% NSKP	0.08 bc
50% NSKO	0.04 dc
2% D	0.00 d

Mean weight loss % was significantly reduced in blocks treated with 50%NO, 25%NP, 50%NP and 2%D when compared with the control.There is significant defference between blocks treated with 10% NSKO, 25% NSKO, 10% NSKP, 25% NSKP,50% NSKP, 10% EO, 25% EO and 50% EO and 2% D. There is no significant difference in weight loss between blocks trated with 50%NSKO and 2%D.

There is no significant difference in weight loss between the control and 10% NSKO, 25%NSKO, 10% NSKP, 10% EO, 25% EO and 50% EO (see table 7).

4. 2. 1. 3. 2:Effect of (NSKO), (NSKP), (EO) and (D) on *E. camaldulensis:* -

Effect of different concentrations of NSKO, NSKP and EO on

E. camaldulensis was summarized in table (8); Fig (6).

Mean weight loss % was significantly reduced in blocks treated with 2%D when compared with the control.There is significant defference between blocks treated with 10% NSKO, 25% NSKO, 50%NSKO, 10% NSKP, 25% NSKP, 50% NSKP, 10% EO, 25% EO and 50% EO and 2% D.

Table (8): - The Effect of different concentrations of NSKO, NSKP, EO and D on *E.camaldulensis* against termite infestation.

Treatment/concentration**.**	Mean loss of weight %.
0% C	0.21 a
10% NSKO	0.18 ab
10% EO	0.18 ab
25% EO	0.14 abcd
50% NSKO	0.13 abcd
25% NSKP	0.13 abcd
10% NSKP	0.13 abcd
50% EO	0.12 abcd
25% NSKO	0.12 abcd
50% NSKP	0.11 bcd
2% D	0.08 d

There is no significant difference in weight loss between the control and 10% NSKO, 25%NSKO, 50% NSKO, 10% NEKP,25% NSKP, 50% NSKP,10% EO, 25% EO,50% EO (see table 8).

4. 2. 1. 3. 3:Effect of (NSKO), (NSKP), (EO) and (D) on *Balanites aegybtiaca*: -

Effect of different concentrations of NSKO, NSKP and EO on *Balanites aegybtiaca* was summarized in table (9); Fig (7).

Mean weight loss % was significantly reduced in blocks treated with 50% NSKP, 50% EO and 2%D when compared with the control.There is significant defference between blocks treated with 10% NSKO, 10% EO and 2% D.

There is no significant difference in weight loss between blocks treated with 25%NSKO, 50%NSKO, 10% NSKP, 25% NSKP, 50% NSKP, 25%EO and 50%EO and 2%D.

There is no significant difference in weight loss between the control and 10% NSKO, 25%NSKO, 50% NSKO, 10% NSKP,25% NSKP,10%EO and 25% EO (see table 9).

Table (9): - The Effect of different concentrations of NSKO, NSKP, EO and D on *Balanites aegybtiaca* against termite infestation.

Treatment/concentration.	Mean loss of weight %.

0% C	0.16 ab
50% EO	0.14 ab
25% NSKO	0.14 ab
25% EO	0.14 ab
10% NSKP	0.14 ab
10% NSKO	0.14 ab
25% NSKP	0.13 ab
50% NSKO	0.10 a
10% EO	0.10 a
50% NSKP	0.09 b
2% D	0.00 c

4. 2. 1. 4:Effect of (NSKO), (NSKP), (EO) and (D) on *Pinus spp.*: -

Effect of different concentrations of NSKO, NSKP, EO and D on *Pinus spp.* was summarized in table (10); Fig (8).

Mean weight loss % was significantly reduced in blocks treated with 50%NSKP and 2%D when compared with the control.There is significant defference between blocks treated with 10% NSKO, 25% NSKO, 50%NSKO, 10% NSKP, 25% NSKP, 10% EO and 25% EO and 2% D. There is no significant difference in weight loss between blocks treated with 50% NSKP and 50%EO and 2%D.

There is no significant difference in weight loss between the control and 10% NSKO, 25%NSKO, 50% NSKO, 10% NSKP,25% NSKP,50%NSKP, 10% EO and 25%EO (see table 10).

Table (10): - The Effect of different concentrations of NSKO, NSKP, EO and D on *Pinus spp*. against termite infestation.

Treatment/concentration**.**	Mean loss of weight %.

25% NSKP	0.26 a
105 EO	0.24 ab
0% C	0.20 abc
25% EO	0.17 abcd
10% NSKO	0.16 bcd
25% NSKO	0.15 bcd
10% NSKP	0.15 bcd
50% NSKO	0.14 bcd
50% EO	0.12 dec
50% NSKP	0.08 de
2% D	0.03 e

CHAPTER FIVE

DISCUSSION

Refractive index of *Eucalyptus* oil was 1.4680 in the present study, whereas in the Indian standard it ranged between 1.4470 to 1.4500 (IS 9257, 1993). The variation in the refractive index from the Indian standard may be due to differences in the temperature as the refractive index increases when temperature decreases (Indian standard IS 9257, 1993). Specific gravity of *Eucalyptus* oil recorded in the present study is similar to the standard specific gravity range in Indian standard (IS 328, 1957) which is from o.9005 to o.9075. Odour and taste of *Eucalyptus* oil is similar to the standard odour and taste in Indian standard (IS 328-1957) which is a characteristic odour ,pungent and comphraceous taste. Colour of *Eucalyptus* oil was yellow and red (4.0&3.0), whereas standard colour in Indian standard (IS 328-1957) is colourless. The variation in the colour from the Indian standard, may be due to the materials used for extraction which are made from copper.

In the present study the crude oil of neem seed kernel oil (NSKO) and neem seed kernel powder (NSKP), and *E. camaldulensis* leaf oil (EO) were found to have significant inhibitory effects against termites in blocks of wood of the four species tested.

The present study proved that (EO) at 50% significantly reduced weight loss% of the blocks of *Balanites aegybtiaca*. This finding is in line with that of Lisin et al.,(1999) who studied the effect of essential oils of *E. globulus* and *E. radiata* on the activity of *Staphlococcus, Escherichia coli, Peseudomonas areuginosa* and *Candida albicans* where similar inhibitory effects were recognized. Also Das (1999) found that mulching treatments which included green leaves of *E. citriodora* had a significant positive effect against rhizome rot (*Pythium aphanidermatum*). Harkenthal (1999) reported that essential oils of *Eucalyptus* inhibited the activity of *Entrobactor aerogenes, Escherichia coli, Klebsiella pneumoniae, Proteusmir abilis, Slamonella cholerasuis, Bacillus subtilis* and *Listeria monocytogenes.*. Regnault and Hamraoui (1993) reported that aromatic essential oils of *E. golbulus* caused mortality to *Acanthocelides optectus* on *Phaseolus vulgaris* seeds. Changriha *et al*. (1998) detected that all essential oils from E. *globulus* and *E. punctata* exhibited activity against *Escherichia coli, Staphylococcus aureus, Pesedudomonas Aeruginosa* and *Candida albicans.* Leite *et al*.(1998) tested essential oils from the dried leaves of *E. camaldulensis* for mycobactericidal activity. *M. avium* was sensitive to oils containing citronellal and/or citronellol as major constituent. Thorsell *et al*.(1998) tested extracts and oils from *Eucalyptus* and *Achillea millefolium* (yarrow) in laboratory and in the field. The laboratory tests showed that yarrow extract exhibited a similar repellency to *Aedes aegypti* to what as the reference substances N,N-diethyl-m-toluamide and N,N-diethyl-mandelic acid amide .A good repelling effect against *Aedes aegypti* was also obtained with the oils of *Eucalyptus*. The field tests revealed that the extracts and oils with good activity against *Aedes aegypti*, *A. communis* and *A. cinereus*. Ahmed (1995) reported a 100% mortality of *Caryedon serratus* after 24 hours of fumigation by 100 ml/L EO.

The present study showed that EO was effective against termites .This might be due to the active ingredient(s) contained in EO. Varro *et al.*(1981) divided the major compounds of *Eucalyptus* volatile oils into : (1) Oils for medical use which contain 75-80% cineol plus lesser amounts of volatile aldehydes, terpens, sesquiterpenes , aromatic aldehydes and alcohols and phenols.(2) Oils used in perfumery which are rich in geraniol, its esters and citronellal.(3) Oils for industrial purposes with pipertone and/or phellendrene as the principal components. Gupta *et al*. (1990) and Zrira *et al*. (1991) stated *Eucalyptus spp*. to contain a wide variety of essential oils with 1, 8-cineol as the most predominant. Sanker and Rai (1993) reported that *E. camaldulensis* was found to produce phenols and terpens which were phytotoxic. Furthermore, Bignell *et al.* (1997) stated that many species of *Eucalyptus* contained alphapinene (0-43%), beta-pinene (0-5.3%), 1,8-cineole [eucalyptol](0.3-66.4%), p-cymene (0.2-22.6%), pinocarvone (0-8.4%),btacaryophyllene (0-11.6%) aromadenrene (0-

19.4%),transpinocarveol (0.2-28.6%) and bicyclogermaccrene (0-19.4%) as principle leaf oil component. All species of *Eucalyptus* contained torquatone (0.09-6.2%); lateriticone (1-isovaleryl-4-methoxy-3,5,5-trimethylcyclohex-3-en-2,6-dione)(0.1-0.5%) was found in *E. indurate*, *E. goniantha* and *E. perangust*. According to Muchori *et al.*(1997), *E. camaldulensis* were rich in 1,8cineol [eucalyptol] (>70%). Tunc *et al.* (1998) found that vapours of essential oils extracted from *E. camaldulensis* were toxic to *Tetranychus cinnabarinus* and *Aphis gossypii*.

The present study proved that EO at 10-25% had no significant different on reduction of weight loss% of the blocks of the four species studied . this is may be due to the volatility of the oil and/or low concentration of the active ingredients.

The present study showed that NSKO at 50% concentration significantly reduced weight loss% of the blocks of *khya senegalensis* This finding is in line with that of Redfern *et al.*, (1980) who reported that as little as 0.2 ppm of azadirachtin incorporated into the diet of the full armyworm, *Spodoptera frugiperda*, had significant antifeedant effects on the first-instars larvae. Physiological changes that occur in larvae of *Lepidoptera* following exposure to neem extracts and NSKO have toxic effect on *Choristoneura rosacceana* larvae and adults (Lowery and Smirle, 2000). Ashtapputre and Kulkarni (1999) showed that neem leaf extracts were the most effective plant extracts against the late leaf spot disease of groundnut caused by *Phaeoisariopsis personata* when they studied 4 leaf extracts (Coconut, Sorghum, neem and partheium leaf extract) against late leaf spot. Leaves of sugar beet, cotton and Lucerne were treated with NSKO against larvae of *Spodidtera littoralis.* The neem oil (NSKO) which oil was generally effective at all concentrations tested on laboratory treated host plants (Meisner *et al.*,1980). Aqueous leaf extracts have also been reported to inhibit , to varying degrees, a number of foliar pathogens, *Sacocladium oryzae* and *Fusarium oxysporum. f. sp. Cepae.* Aqueous extracts of dried and powdered seed kernel and seed shell of neem were found to possess nematicidal effect against the second stage juveniles of *Meloidgyne incognita* (Mojumber and Mishra, 1991).Other plant parasitic nematodes including *Hel. indicus, Hop. indicus, Tylenchorhynchus brassicae, Rotylenchulus reniformis and M. incognita* were also affected by aqueous extracts of fresh fruit of neem (Siddig and Alam,1985). Mishra and Prasad 1973; Mojumber and Mishra, (1991) found that water soluble fractions of neem cake (water extracts) to be toxic to *M. incognita*. Aqueous extracts of chopped and macerated flowers of fresh root of neem (*A.indica*) were found to be toxic to a number of species of nematodes, such as *Hel. indicus, Hop. indicus, Tylenchorhynchus brassicae, Rotylenchulus reniformis* and *M. incognita* .Water extracts of fresh macerated flowers and bark of neem were toxic to ectoparasitic (*Hel. indicus, Hop. Indicus*, and *Tylenchorhynchus* *brassicae*), semiendoparasitic(*Rotylenchulus reniformis*) and endoparasitic (*M. incognita*) nematodes (Siddig and Alam 1985).The influence of methanol and aqueous extracts of neem (*A. indica*) kernels (prepared at room temperature) on reproduction and longevity of the two spotted spider mite, *Tetranychus urticae* koch, was investigated in laboratory experiments where a number of females were transferred to bean leaf discs, which had been sprayed previously with 2.5, 5 and 10% concentrations of the extracts. All the concentrations of the aqueous extract and of methanolic extract was found to have a strong repellant effect. The methanolic extract reduced egg-laying during the first 24 h. by 50% concentration; 4 days later the number of eggs/female/day was similar on treated and untreated leaf discs (Aschaur and Schmutterer, 1980). The application of freshly prepared 4% neem seed kernel extract gave significant reductions in hopper (*Idicospus spp*.) populations (Goudegnon *et al*., 2000).The control of the mango hopper (*Amritodus atkinsoni*) was best achieved with synthetic pesticides but these were not significantly better than neem products and leave extracts (Kumar and Bhatt 1999). The efficacy of concentrations (25, 50, 75, and 100 mg/5 g seed of neem) was assessed on four cowpea varieties with differing susceptibilities to *Callosobruchus maculatus*. The different concentrations of NSKO significantly interacted with cowpea parietal resistance and reduced oviposition and percentage adult emergence of *C. maculatus*. The interaction also significantly reduced percentage of cowpea seeds infested by

C. maculatus. Treatment of cowpea (*Vigna unguiculata*)seeds with NSKO at the rates of 50 mg/5 g seed and 75 or 100 mg/5 g seeds reduced seed damage from over 25% in controls to less than 10% and less than 5%, respectively, in all varieties (Lale and Mustapha, 2000). Neem extracts were found effective against *Pluutella xylostella* in Mauritius (Fackanath, 1999) . Saxena *et al*.,(1989) reported that the red flour beetle, *Tribolium castaneum* and the confused flour beetle , *T. confusum*, are distributed worldwide in warm climates. However, the adults and larvae attack a wide range of stored products including neem seeds and seed kernels. Normally these beetles are repelled by the active principles in neem seeds but under certain conditions for instance if old seeds of poor quality are stored with broken shells, *Tribolium spp*. may find a chance to develop.

The effect of NSKO and NSKP might be due to the active ingredient(s) contained in them particularly azadirachtin (C_{35} H_{44} O_{16}). According to Ascher (1986), the active ingredients isolated from neem oil are epoxyazadiradione, azadiradione, azadirone, 7-deacetylgedunin and gedunin. Siddig (1991) stated that the active ingredients in neem seed were azadirachtin, solanin, salannol, salannol acetate, 3-deaceyle salannin, epazaradion, gedunin, niembinen and deacetyle niembinen. According to Kraus and Cramer (1978), the active ingredients in extracts of dried seeds were azadiron, azairadion, epoxyazadiradion, gediunin, 17-epiazadiradion and 17-*B*-hydroxyazadiradion.The 17-*B*-hydroxyazadiradion was found by Siddiqui *et al* (1978) in neem fruit extracts at the same time.

The present study indicated that NSKO at 10 and 25% (v/v) had no significant effect on the activity of termites and this may be due to the low concentration of the active ingredient(s) at this dose.

The present study showed that NSKO, NSKP and EO (at a certain concentration) are as efficient as dursban in reducing weight loss of the wood blocks by termites. The advantage of these botanicals is that they are cheap and safe to the environments as compared to pesticides which are costly and hazardous to the environment. On the other hand, neem seeds and *Eucalyptus* leaves are widely available in the Sudan. Neem leaves and seeds are not toxic to Man and animals and can be easily processed or formulated locally by traditional limited means like pestle and mortar to be used as cheap insecticides (Siddig, 1991).

Based on the efficacy of some botanicals tested in controlling the activity of termites on various timber resistance in the present study and because they are cheap to prepare and environmentally safe and friendly, it is recommended to expand in using botanicals for the control of the economically important termites. It is also recommended to use relatively high concentrations of the botanicals for timbers of moderate and low durability to termites and to extract botanicals from leaves and seeds rather than to use powder without extraction.

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